A Summary of Current Program and
Preliminary Report of Progress

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FLORIST, NURSERY AND SHADE TREE RESEARCH

of the

United States Department of Agriculture
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having an interest in the development of public agricultural research programs.

This report also included a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
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ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology Research
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil and Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Clothing and Housing
3 - Consumer and Food Economics
4 - Market Quality
4 - Transportation and Facilities
7 - Animal Husbandry
7 - Animal Disease and Parasite
12 - Crops
12 - Entomology

Economic Research Service (ERS)

1, 5 - Resource Development Economics
4, 5 - Marketing Economics
5 - Farm Production Economics
5 - Economic and Statistical Analysis
5 - Foreign Development and Trade Analysis
5 - Foreign Analysis Division

Forest Service - Research (FS)

6 - Forest Economics and Marketing
6 - Forest Products and Engineering
6 - Forest Protection
6 - Timber Management
6 - Watershed, Recreation and Range

Other Services

4, 5 - Farmer Cooperative Service (FCS)
4, 5 - Statistical Reporting Service(SRS)

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the USDA program and progress for the following commodities and subjects:

3 - Rural Dwellings
6 - Forestry (Other than Forest Service)
7 - Beef Cattle
7 - Dairy
7 - Poultry
7 - Sheep and Wool
7 - Swine
7 - Cross Species and Miscellaneous Animal Research
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Citrus and Subtropical Fruit
10 - Deciduous Fruit and Tree Nut
10 - Potato
10 - Vegetable
10 - Florist, Nursery and Shade Tree
11 - Oilseeds and Peanut
11 - Sugar
13 - Tobacco

A copy of any of the reports may be requested from Barnard Joy, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

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INTRODUCTION

This report deals with research on flowers, nursery plants; shade, ornamental and windbreak trees. It does not include extensive cross-commodity work, much of it basic in character, which contributes to the solution of problems of other agricultural commodities, as well as those of flowers, nursery plants; shade, ornamental and windbreak trees. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA AND COOPERATIVE PROGRAM, (3) PROGRAM OF STATE EXPERIMENT STATIONS, (4) PROGRESS--USDA AND COOPERATIVE PROGRAMS, (5) PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS.

Research on flowers, ornamentals and shade trees is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

Research by USDA

Farm Research comprises investigations on introduction, breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology, and Agricultural Engineering divisions of the Agricultural Research Service.

Marketing and Economic Research. The physical, biological, and economic aspects of quality maintenance in handling and packaging, in storage and during transportation as well as post-harvest physiology are investigated by the Market Quality Research Division of ARS. Work on merchandising and promotion practices for floral products is done by the Marketing Economics Division of the Economic Research Service.

Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources

of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by container and equipment manufacturers and suppliers, chemical and fertilizer companies, market research institutes and corporations, nurserymen, florists and their associations and research institutes. Industry's cooperation in supporting research on flowers, ornamentals and shade trees in the form of grants, gifts, or loans of materials, equipment and facilities to Federal and State stations has contributed greatly to its success.

Marketing equipment and facility manufacturers make sizeable contributions to research in the development of equipment for handling flowers, ornamentals and shade trees in greenhouses, storages, retail and wholesale establishments, and in transportation vehicles in which it moves from one point to another in the channel of distribution as well as on the containers in which it moves. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development and interregional and intermarket competition.

Chemical, fertilizer and electrical equipment companies are significant factors in research on the development of new materials and equipment or combinations of these to produce more efficiently, high quality flowers and ornamentals through better nutrition, control of diseases, insects, nematodes, and weeds and through the regulation of growth processes through the use of growth regulator substances, light and environmental control equipment.

A number of the larger florists, seedsmen, bulb growers and nurserymen spend considerable time and money in breeding and testing new varieties of flowers and ornamentals in the major production areas, sometimes on their own acreage but much of it usually in cooperation with smaller growers. The contribution of growers to the overall research effort is considerable. Certainly in the field of production his help is indispensable for much of the laboratory research results must be confirmed in the nursery and greenhouse in each of the major production areas. The grower cooperates with the USDA, State Experiment Stations and suppliers of many materials and equipment - usually without compensation except for the experience and knowledge gained.

9. Economics of Marketing Horticultural Specialties. -- Research to analyze the economics of marketing floricultural products was initiated. It involves the development of basic economic information about the industry through: (1) special tabulations of census data to more clearly delineate changes in the horticultural specialty industries from 1949 to 1959, and (2) personal interview surveys to study the credit and financing problems of retail and wholesale florists. Census data indicate that the farm value of floral products increased 50 percent during the 1949-59 period, while the number of producing establishments declined slightly. A survey of 46 retail florists in four Iowa cities disclosed that 14 percent of their sales were wire sales. Of the 86 percent nonwire sales, 60 percent were made by telephone. It is indicated that perhaps 75 percent of all sales in the 46 stores were made to customers who did not see what they were buying and often did not see what they had bought.

The phase of the research underway to improve merchandising and promotional effectiveness for floral products includes: (1) a nationwide survey of approximately 4,000 retail florists to determine merchandising, advertising, pricing, procurement, credit, service, and other operating practices currently followed by retailers; (2) analysis of economic and demographic factors as they relate to the demand for flowers; (3) evaluation of specific promotional efforts by individuals or groups; and (4) a review and summary of published research relating to marketing floral products.

7. Promotional Expenditures by Producer Organizations. -- A survey of promotional expenditures of producer organizations and similar agriculturally oriented groups indicates that there are almost 1,200 of these organizations spending a total of about $86 million annually for the promotion of agricultural products. This is an increase of nearly $20 million over expenditures shown by these organizations in a similar survey in 1958. This increase in expenditures represents added self-help efforts by producer groups to build and strengthen markets for their products and to combat the problem of an imbalance between demand and supply. Fruit, which was the leading product promoted, and dairy, which ranked second, accounted for well over 50 percent of these expenditures. Meat and livestock products ranked third with expenditures of over $6 million per year. Promotional expenditures for natural fibers, poultry and eggs, and field crops were comparable ranging between $4 and $5 million per year for each commodity class.

Voluntary producer-processor groups spent more than any of the other groups, with expenditures of nearly $32 million per year. Cooperatives and commissions and boards operating under enabling legislation were also important, with each type of organization spending about $25 million per year. State Departments of Agriculture and other organizations not identified spent less than the other types of organizations, with expenditures in each of these categories averaging about $1.5 million per year.

I. FARM RESEARCH

PLANT INTRODUCTION AND EVALUATION
Crops Research Division, ARS

Problem. American agriculture is based on the expanding culture of crops most of which have originated outside our continental limits. The improvement of existing crop varieties, the selection of new lines with natural resistance to insects and diseases, and the development of any number of important characteristics is dependent on a continuous flow of introduced germ plasm. Inherent in this is the preliminary evaluation and cataloging of plant introductions for traits which will be of use to plant breeders and the agronomic development of potential crops as a result of joint botanical-utilization screening research on new crops. These demands require the search for and introduction of 8 to 10 thousand plant collections and samples for analysis yearly.

USDA AND COOPERATIVE PROGRAM

The nature of this program is to conduct investigations concerned with the introduction, evaluation, and maintenance of plant germ plasm for the development of a strong yet diversified agricultural program for the United States. Research involves a continuing assessment of the world's plant resources; procurement of stocks through exploration and international exchange; the evaluation of the introductions either as breeding stocks, as potential new crops, or for land reclamation and conservation purposes, through a national cooperative research effort, and the preservation of these materials either as seed or as vegetative stocks. Leadership for this program is at Beltsville, Maryland.

Four national introduction stations are responsible for evaluation, maintenance, and/or quarantine of new introductions which require special handling: Chico, California; Miami, Florida; Savannah, Georgia; and Glenn Dale, Maryland. The responsibility for preservation of seed stocks of national interest lies with the National Seed Storage Laboratory, Fort Collins, Colorado. Cooperative new crops studies to determine significant agronomic characteristics of plants having valuable end-products are conducted cooperatively with experiment stations of Alabama, Montana, Nebraska, North Carolina, South Carolina, and Texas. Four regional and one inter-regional introduction stations deal with the evaluation of crop breeding stocks essential to programs in state experiment stations.

Ten P.L. 480 projects are currently active, all having to do with the collection and screening of native plants of potential use in the agriculture of the United States. These countries and grant amounts are as follows: Colombia (S5-CR-1) - $113,159; India (A7-CR-52) - $20,752; Israel (A10-CR-10) - $115,555; Israel (A10-CR-11) - $87,337; Korea (A13-CR-1) - $46,692; Pakistan (A17-CR-5) - $60,449; Spain (E25-CR-11) - $156,583; Turkey (A22-CR-1) - $134,444; Uruguay (S9-CR-3) - $114,024; Yugoslavia (E30-CR-2) - $30,000.

The Federal scientific effort devoted to research in New Crops totals 38.5 man-years. Of this number, 3.0 are devoted to international plant exchange, 3.2 to botanical investigations, 6.2 to special plant procurement and botanical activities. Research on new crop evaluation includes 8.7 man-years for horticultural research, 3.8 for agronomic studies, 6.1 devoted to evaluation of potential new crops, 4.0 to pathology, and 3.5 to maintenance of germ plasm.

PROGRAM OF STATE EXPERIMENT STATIONS

While responsibility for collecting and introducing plant material into this country rests predominantly with the Department, the State stations cooperate actively in the preservation, multiplication, and preliminary evaluation of such materials and in domestic and other explorations for the introduction of new materials. An elaborate system supported in part by the States and in part by the Department has been organized for the purpose of placing introduced materials in the hands of interested plant researchers throughout the country. This system consists of a series of 5 plant introduction stations located respectively in Geneva, New York; Experiment, Georgia; Ames, Iowa; Pullman, Washington; and Sturgeon Bay, Wisconsin. Research of the State stations is organized and coordinated through 4 regional projects and 1 inter-regional project: NE-9, Discovery and Preservation of Valuable Plant Germ Plasm; S-9, The Introduction, Multiplication, and Evaluation of New Plants for Industrial and Agricultural Use and the Preservation of Valuable Germ Plasm; NC-7, New Plants - for Industrial and Agricultural Utilization; W-6, The Introduction, Multiplication, Preservation, and Determination of the Value of New Plants for Industrial and Other Purposes; and IR-1, Introduction, Preservation, Classification, Distribution, and Preliminary Evaluation of Wild and Cultivated Species of Solanum. All 50 States and Puerto Rico cooperate in this research. Cooperation between the State stations and the Department in this program is outstanding and of great mutual benefit.

The total research effort on replacement crop introduction and evaluation at the State stations is approximately 60.0 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Plant Introduction and Evaluation

1. Foreign Exploration. An exploration in the Soviet Union resulted in the collection of 150 fruit and ornamental breeding stocks, mostly seeds collected in the wild in Central Asia, Crimea, and Moldavia. This was the first collecting by U. S. explorers in the U.S.S.R. in 30 years.

2 Domestic Exploration. As a part of regional project W-6, a collection of 100 wild types of Ceanothus from Oregon and Washington has been assembled for propagation. Although difficult to propagate, several lines with ornamental merit have been supplied to interested workers.

3. Maintenance of Germ Plasm. An initial inventory of annual ornamentals was published.

B. New Crop Evaluation

A selection of a dwarf pomegranate introduced from China as P.I. 43793 has been named "Chico" by California nurseryment. It makes an excellent pot plant as well as serving as a foundation plant.

Progeny studies at Glenn Dale, Maryland, on 511 seedlings of crosses between introductions of Ilex cornuta and I. ciliospinosa have been analyzed for expression of genetic characters and the results have been interpreted statistically. Characters studied were: leaf blade outline, number of leaf spines, cold hardiness, fruit size, and fruit shape. Results showed varying degrees of dominance and indications of matroclinous inheritance.

Interspecific crosses at Glenn Dale, Maryland, of nine introduced Camellia species yielded approximately 6% set. Among crosses where a hexaploid male parent was used with a diploid female parent, four stages of embryo development were noted - 66% abortive embryos, 17% partially developed embryos but structurally disorganized, 6% partially developed and otherwise normal appearing embryos, and 11% normally developed embryos. Embryo culture was effective in obtaining some plants from certain of the partially developed embryos which were sufficiently organized to continue differentiation. Propagation studies on subtropical ornamentals at Miami resulted in the following: Ipomoea wolcotticana, P.I. 103932 and P.I. 144004, has been grafted onto a bush morningglory successfully. This tree morningglory is an excellent ornamental if a means of propagation can be found. Eighteen percent of the grafts tried on the bush type were successful. Butea monosperma is a desirable ornamental legume but has not been propagated asexually. Selections of introductions have been successfully grafted onto seedlings, attaining up to 60% success. Tip cuttings under mist failed completely.

Regional cooperative programs: Ornamentals of note were as follows: Ligustrum vulgare, P.I. 107630 (Yugoslavia), has been outstanding as a hardy shrub in the Central States and is now being propagated in quantity by nurserymen (NC-7). In the Southeastern States, Elaeagnum umbellata, P.I. 237867, Osmanthus 'Gulftide', P.I. 213308, and Eurya emarginata, P.I. 240914, continue to be in demand by nurserymen. Quercus acutissima, P.I. 168939, has been widely distributed in the southeast and has attracted attention because of its precocious, heavy yields of acorns attractive to deer and squirrels (S-9).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Creech, J. L. 1963. Japan - Like a National Park. The Yearbook of Agriculture. USDA. 525-528.

Creech, J. L. 1963. A Japanese Crinum. Amer. Hort. Mag. 42(3): 182-183.

Creech, J. L., and D. H. Scott. 1964. U. S. Horticulturists Collect Plants from the USSR. Foreign Agriculture, February 3.

Meyer, F. G. 1963. Plant Explorations: Ornamentals in Netherlands, West Germany and Belgium. ARS 34-32, April.

Meyer, F. G. 1963. Wild Coffea arabica L. - the problem in retrospect, with recent observations of spontaneous plants in southwestern Ethiopia. Coffee & Tea Indus. 86(10): 17-20. October.

Ticknor, R. L. 1964. Ceanothus prostratus and C. pumilus: Promising Ground Covers. Amer. Hort. Mag. January.

Dodge, A. F. 1963. Five year reports on regional plantings of Woody Ornamental and Shelter Plants in the North Central Region, 1957-1961. 47 pp. Ames. (Processed)

Hawley, W. O., H. T. DeRigo, and J. R. Haun. 1964. Nursery culture of temperate bamboo. Amer. Nurseryman 69(2): 11-12, 77-80.

Kahn, R. P., H. A. Scott, and R. L. Monroe. 1962. Eucharis mottle strain of tobacco ringspot virus. Phytopathology 52(11): 1211-1216.

Kahn, R. P., H. A. Scott, F. F. Smith, and J. J. Higgins. 1963. Sunn hemp yellow mosaic incited by the bean yellow mosaic virus. Plant Dis. Reptr. 47(5): 364-368.

Soderholm, P. K. and M. H. Gaskins. 1963. Ipomoea wolcottiana, A tree morning-glory. Amer. Hort. Mag. 42(2): 111-113.

FLOWER AND ORNAMENTAL PLANT CULTURE, BREEDING AND GENETICS, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Technical problems in the production of flowers and ornamental plants, (with a farm value of over a half billion dollars a year) are varied and numerous. There is need for increased research on untouched problems in the culture, propagation, nutrition, physiology, photoperiodicity, genetics, breeding, pathology and adaptability of these commercially important plants. The Industry is demanding answers to these problems. The great expansion of commercial cut flower production out-of-doors is attended by many new problems. Explosive urbanization and expanding interest in civic beautification bring new and more urgent needs for answers to old problems. This group of crops, for which consumer demand is highly elastic, must have expanded research effort consistent with their great expansion of use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, physiologists, plant pathologists and horticulturists carrying on both basic and applied research on many problems concerned with production of floricultural and other ornamental plants. Breeding and genetics are being done at Beltsville, Maryland, at the National Arboretum, Washington, D. C., at Tifton, Georgia, in cooperation with the Georgia Coastal Plain Experiment Station, and at Morgantown, West Virginia, in cooperation with the West Virginia Agricultural Experiment Station. Research on diseases is conducted at Beltsville, Maryland, and cooperative with the Georgia Coastal Plain Experiment Station; the Agricultural Experiment Stations of Oregon, Washington, and West Virginia. Experiments for improving cultural methods and growth regulation are carried on at Beltsville, Maryland, and in cooperation with the above Experiment Stations.

Reference collections of living plants and herbarium specimens are maintained at the National Arboretum, Washington, D. C. Promising selections from foreign introductions received through the New Crops Research Branch are propagated at the Arboretum for testing and for distribution to other botanic gardens, arboreta and experiment stations. Plant specimens are identified and classified.

A contract with the Ministry of Agriculture, India, provides for the studies of pyridinonucleotide metabolism in normal and tumor tissue of hollyhock. The contract is for the five years, 1963-1967, and involves PL 480 funds with a $36,666 equivalent of Indian rupees.

The Federal scientific effort devoted to research on ornamentals totals 16.3 professional man-years. Of this number 6.5 is devoted to breeding and genetics, 2.7 to diseases, 3.1 to variety evaluation and classification, 4.0 to culture.

PROGRAM OF STATE EXPERIMENT STATIONS

Research on the culture of ornamentals and floricultural plants at the State stations covers a broad area involving 77 projects in 31 States. Because of the number of plants involved and the varying conditions for which research is done, there is probably no real duplication.

Breeding and variety testing of ornamentals and flowers emphasizes the development of new plants for ornamental purposes through varieties better adapted to given areas. There are 37 such projects in 21 States. Fundamental research in genetics and cytogenetics of ornamentals is also conducted. Scientists at the State stations are conducting research on the viruses of amaryllis, the rattle virus of gerbera, and on heat treatments in the control of orchid viruses. Work with meristem culture in carnations for the production of mature plants free of virus is in progress. Research is in progress on tuber rot in dahlia, petal blight of azalea, root rot of lily, needle blight of ornamental conifers, wilt of mimosa, and numerous other destructive diseases.

The total research effort on flower and ornamental plants at the State stations is approximately 39.6 professional man-years, of which 23.7 is for culture, 9.7 for breeding and variety evaluation, and 6.2 for disease investigations.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. African violet. Of 15 species studied two, S. shumensis and S. nitida, are partially incompatible in crosses with other species. Species hybrids were uniform and mid-parental in foliage, form and flower. The species hybrids have been quite fertile and back crosses of many hybrids have been made. Colchicine-induced tetraploid African violets produce thicker and larger flowers and foliage, but have reduced fertility. Breeding of tetraploids was begun using tetraploid cultivars of S. ionantha and induced tetraploids of S. nitida, S. difficilis, S. confusa, S. velutina and S. diplotricha.

2. Azaleas. Certain combinations of dwarf parents yield all dwarf progeny, others yield many normal plants. Many apparent dwarfs begin rapid, normal growth only after 3 or 4 years; others do not flower until they are more than 5 years old. Additional evergreen-deciduous hybrids have been flowered. Several of the white seedlings have an increased amount of yellow in the throat. Additional hybrids have been obtained from crosses

of evergreen and deciduous azaleas with several glossy-leaved Rhododendron species and hybrids. Hybrid seedlings show characteristics of both parents. Several selections from an F_2 seedling population from crosses between R. atlanticum and named Knaphill hybrid azaleas are being propagated for further testing and evaluation.

3. Camellias. As part of a cooperative project, the following seeds and plants were received for cold hardiness screening from the Camellia Research Committee which is affiliated with the California Arboretum Foundation, Inc.: (1) twelve hundred seeds from open-pollinated cold hardy C. japonica cultivars 'Berenice Boddy' and 'Snow Belle', and (2) eight hundred 2-year-old seedlings from controlled pollinations between a number of cold hardy cultivars.

4. Carnations. Several carnation seedlings have been released for use in breeding and for commercial trial. Progeny from inter-species crosses have shown high yield and flower size, approaching that of commercial types, after five or six backcrosses. A number of seedlings with chlorophyll variegations were selected and propagated. Several show patterns that are apparently confined to tissue derived from a single histogenic layer. The inheritance of the chlorophyll variegation is being studied.

5. Crape Myrtle. About 300 selections from 127 crosses in 1960 have been made for further evaluation. Selections have been made from the 1,058 plants raised from six colchicine seed and seedling treatments; these plants have the distinctive appearance of polyploids but have not yet been studied cytologically. Plants from eight irradiation treatments have been slow-growing.

6. Hemerocallis. Colchicine-induced tetraploids and cytochimeral daylilies were obtained from 16 out of 24 cultivars treated in 1962. Breeding tests of 4-4, 2-4, and 4-2 cytochimeras show that the 4-4 cytochimera is relatively sterile and produces only tetraploid seedlings. The 2-4 and 4-2 types have produced only diploid seedlings so far.

7. Herbaceous perennials. Blocks of herbaceous perennials of potential genetic value were maintained and 40 new accessions added at Cheyenne, Wyoming. A summary of all herbaceous perennials tested at the Cheyenne Station in the past 40 years has now been completed for publication.

8. Hibiscus. From some 5500 seedlings of H. syriacus self- or open-pollinated seedlings, 142 selections have been made for further evaluation. Tetraploids have been produced by colchicine treatments and 34 selections made from irradiated seed. A few seeds were produced from crosses between H. syriacus tetraploids and H. rosa-sinensis. Several forms of the native Hawaiian H. brackenridgii were studied cytologically and genetically and were tentatively placed in two groups -- Kauai type $2n = 80$ and Lanai type $2n = 140$.

9. Hollies. Evaluation of cultivars, species, and interspecific hybrids is continuing at the National Arboretum and in cooperative tests in Georgia and Louisiana. A branch mutation on a plant of Ilex crenata microphylla growing at the National Arboretum was propagated and named I. crenata 'High Light'. The plant has a dense conical shape and the new leaves are light green in color. A study of the taxonomy of North American, West Indian and north-west-South American species of Ilex has been completed. It will be published by the Chicago Museum of Natural History.

10. Lilies. (a) Polyploids. Four selected tetraploid clons of Easter lilies are being increased in six States. Amphidiploids have been obtained by colchicine treatment of scales of the species hybrids L. regale x L. henryi and L. speciosum x L. henryi. Tetraploids have been obtained from treatments of the cultivar 'Enchantment'. Easter lily triploids and a hexaploid are being increased for comparison with diploids and tetraploids. Backcrosses of the species hybrid L. longiflorum x L. formosanum have flowered and colors of pollen hitherto unknown on either parent species have occurred. Some of these backcross plants are very attractive and are being increased.

(b) Endosperm breakdown as a barrier to hybridization. Examination of the embryo sac at intervals following fertilization showed that endosperm cells divided in a normal fashion and proceeded to fill the embryo sac with no indication of abnormality. In later stages endosperm cells began to show disintegration and many embryos were dead.

(c) Lily inbreds. Larger selfed populations of the normally self-incompatible Creole, Croft and Georgia Easter lilies were obtained by use of a growth regulator at time of self-pollination. The seeds were germinated on sterile nutrient media and the seedlings are being grown in the greenhouse. Work is in progress to establish homozygous lines for the production of virus-free, uniform hybrids.

11. Magnolias. Hybrid seed resulting from crosses between M. sprengeri diva and M. denudata has been germinated.

12. Phlox. The cultivar 'Mrs. Jenkins' was the only perennial phlox of many grown in an alkaline soil at Cheyenne, Wyoming, to show high resistance to chlorosis. Hybrid seedlings from crosses of this cultivar with chlorosis-susceptible cultivars showed strong dominance of the resistance.

13. Poinsettias. (a) Genetic studies. Backcross data from plants homozygous-recessive at each of the two loci controlling bract color have confirmed our earlier postulated genetic system. Further data on progeny from both white and red sectors on a "pink" plant heterozygous at the white locus indicated the mutation was only in the epidermis. The tissue producing the gametes was still heterozygous.

(b) Tetraploids. Tetraploids derived to date failed to produce progeny of as good quality as related diploid seedlings. Spontaneous or colchicine-induced tetraploids of the old diploid commercial varieties show few of the generally undesirable polyploid effects found in tetraploid seedlings. Fertility of tetraploids has been greatly improved by selection.

(c) True-breeding poinsettia from seed. Crosses were made on male sterile types to determine the possibility of producing true-breeding seed. Selections within male sterile lines has resulted in a general improvement in their quality, but they are still generally inferior to most other seedling lines.

(d) Evaluation of potential varieties. Ten experiment stations and commercial propagators are testing six selected seedlings for potentials as commercial varieties.

(e) Non-chromosomal inheritance. Several different chlorophyll mutations have been found and are being propagated. Somatic segregation indicates the determiner is non-chromosomal and is limited to tissues derived from a specific histogenic layer. Data from new seedlings indicates maternal inheritance only.

14. Pyracantha. Herbarium specimens and color scoring by the RHS color chart has been completed for 176 accessions. A detailed evaluation for hardiness, fruiting effect and disease resistance is underway and will be continued for a five-year period. A total of 108 crosses was made in 1964.

15. Red Bud. A number of selections have been made among 806 C. canadensis x C. chinensis F_2 populations for further evaluation and selection.

16. Roses. (a) Seed germination. Seeds of 12 species roses are being tested to determine their temperature requirements for optimum after-ripening and germination. Seeds are in storage in moist perlite in temperatures at 5 degree intervals from 35° to 65°F. Several tests of the effect of pre- and post-harvest environment on seed germination are underway. These include passage through robins, moisture content, and temperature.

(b) Flower initiation. Preliminary studies on spring blooming roses indicated that a storage of about 20 weeks at 40°F followed by forcing at low night temperatures and short days were required to induce flowering. A large test is underway comparing cold storage at constant 40°F with variable cold outdoors and followed by long, short, and natural day-lengths at 52° and 72°F night temperature.

(c) Developing blackspot resistance. Cultures of the causal organism of rose blackspot stored as ascervuli on frozen rose leaves were still virulent after 2 years. Seedlings from P_1 tested with these same cultures last year have been tested for susceptibility this spring. Resistance to each of the three pathogenic races appears to be due to separate recessive alleles. Single gene differences were found in R. setigera and R. carolina. A test of 4 races of the blackspot organism at monthly intervals, showed that virulence is maintained when the fungus is either grown on plants in the greenhouse or kept on frozen leaves in a deep-freeze. There was a seasonal variation in host susceptibility.

(d) Nematode resistance. Selection was continued for nematode resistance within several rose species. All the material showing resistance to date is spring blooming, and requires 2 or 3 years for each generation. Selfing and crossing of appropriate material has continued.

(e) Inheritance. Further crosses were made and progenies tested to establish true breeding lines in various species. The effect of temperature on the expression of genetic factors for flower form and size was investigated. Petal number was reduced to 5 at 82° and 92°F from around 17 at 62°. The length of the stamen filaments was greatly reduced at higher temperatures. Both accessory and reproductive parts of the flower were profoundly modified by high temperature.

17. Viburnums. The Viburnum research collection has been expanded by 34 accessions. of several V. carlesii hybrid seedlings, one was selected for field testing. Among V. dilatatum, V. erosum, V. hupehense, and V. wrightii hybrid seedlings, 34 selections were made for fruits of superior attractiveness.

18. Herbarium Collections. About 300 identification of plants were made for Government agencies and about 150 for the general public. Loans to specialists totaled 117 sheets and 27 sheets were borrowed from other institutions. A collection consisting of 14 herbarium cases of nut varieties was acquired from the Nut Investigations and 2,000 clover herbarium specimens from the Clover Investigations at Beltsville. Notes, seeds and several hundred bundles of herbarium specimens of crabapples were willed to the Arboretum by the late crabapple specialist, Mr. Arie den Boer of Des Moines, Iowa.

B. Diseases

1. Carnations. Viking carnations were cured of virus infections by a heat treatment differing somewhat from that previously used to cure viruses in heat-tolerant King Cardinal and Sim cultivars. Mottle virus, the most heat-resistant, was eliminated by heat treatment at 38°C for approximately one month, then reducing the temperature to 30°C for 5 days, and then continuing treatment at 38°C for about one month. Tip cuttings from the treated plants were free of all virus. Heat-treated carnations are

flowered before release as foundation stock to be certain that no change in flower characters was induced by the treatment.

2. Easter lilies. The field pattern of the stripe disease of Easter lilies suggests it may be caused by a soil borne virus. Studies of many soil samples taken from occurrence sites have, however, failed to reveal a nematode or other animal of the type usually associated with a soil borne virus. Data from electron microscope studies remain the only evidence that stripe is a virus.

3. Geraniums. It has been proven that original bacteria-free cultured stocks of geraniums became subsequently infected with a seed borne bacterium incidental to production under uncontrolled commercial condition. The symptoms are somewhat like the classical Xanthomonas pelargonii disease. Cultures of seed indicate as high as 35 percent seed transfer, but the transfer of several generations of aseptically grown seed stocks indicate the transfer can be as high as 99 percent. The responsible organism and associated symptoms are being described.

4. Gladiolus. Cucumber mosaic virus was practically eliminated from gladiolus stock by selection and growing cormels for two successive years, and removing those that showed symptoms of the virus in leaves.

5. Pyracantha. Inoculation of Pyracantha berries with Phytophthora parasitica, Glomerella cingulata and Cylindrocladium scoparum, previously isolated from rotted berries, resulted in limited infection. Rot in nurseries the past season was less than the previous year because of water conditions less favorable for development of the fungi.

6. Rhododendron. Experiments cooperative with the Ohio Agricultural Experiment Station and the Forest Service on the dieback-canker disease of Rhododendron at Delaware, Ohio, caused by the fungus Botryosphaeria ribis, demonstrated that the fungus can be readily transmitted by pruning tools. Screening tests with standard fungicides for possible use in control of the disease have shown Captan (N-(trichloromethylthio)-4-cyclohexene-1, 2-dicarboximide) and Phaltan (N-trichloromethyl thiophthalimide) to be of sufficient promise for additional trials. Field studies of the use of Dexon (p-Dimethylaminobenzenediazo sodium sulfonate) for control of Rhododendron root rot, caused by the fungus Phytophthora cinnamomi were inconclusive in 1963 due to a low incidence of disease in the untreated check plots, probably because of drought.

7. Cactus virus in Pereskia. The presence of the cactus virus in commercial stocks of Pereskia has been proved. This accounts for the presence of the disease in cactus locally grafted on Pereskia for the florist trade. With the cooperation of the Botanical Garden of the University of California at Berkeley, virus-free clons of Pereskia are being developed.

8. Crassula leaf spot. Members of the National Succulent Society are reporting serious trouble with leaf spot affecting Crassulaceae novelties. Initial tests indicate a Cladosporium may be involved and there can be some connection between this spot and a similar disfiguration of Kalanchoe grown by florists.

C. Culture

1. Anthocyanin synthesis. Dalapon (2,2-dichloropropionic acid) was shown to inhibit anthocyanin synthesis. This may be due to interference with the synthesis of Co-enzyme-A, which interference was reversed to a small degree in red cabbage seedlings by calcium pantothenate. The addition of suspected intermediates in the biosynthesis of anthocyanin did not prevent the blocking action of dalapon, suggesting that it occurred prior to the natural formation of the intermediates.

2. Azaleas and Camellias - Growth Retardants. At Tifton, Georgia, N-dimethylaminosuccinamic acid (B-Nine) and 2-chlorotrimethylammonium chloride (Cycocel) were used as sprays (2 applications 1 week apart) in mid-July on 14 cultivars of azalea which were subsequently cooled and forced for Christmas bloom. Some cultivars forced satisfactorily, others did not. All treatments produced more uniform plants, frequently with more flowers, than untreated plants.

Drenches and sprays of B-Nine and Cycocel and drenches of tributyl-2,4-dichlorobenzylphosphonium chloride (Phosfon) applied to camellia plants at intervals (April to August) in an attempt to induce flower bud set on smaller plants gave variable results. Response appears to depend upon time in the growth cycle applied. (Cooperative with the Georgia Coastal Plain Experiment Station).

3. Cooperative trial of growth retardants for controlled flowering of azaleas. Our finding that azalea growth and flowering are controlled with synthetic growth retardants, B-Nine (Naugatuck Chemical Company) and Cycocel (American Cyanamid Company) was tested in a nation-wide cooperative trial involving experiment station and university workers and commercial azalea growers at 100 locations in 31 States. Generally successful results in extending the flowering season and improving the quality of the plants has lead to registration and marketing of the products and adoption of the method by commercial growers.

4. Cut flowers - Increased longevity. Ethylene oxide gas was found to increase the longevity of Better Times cut roses. Ethylene oxide appears to negate the action of ethylene, an aging "hormone". Carnations tested for 24 hours with 1 ppm of ethylene showed typical symptoms of "sleepiness", and they were completely desiccated by the third day. Those treated for 24 hours simultaneously with 1 ppm of ethylene and 0.2 percent ethylene oxide remained normal. This work was cooperative with Agricultural Marketing Service.

5. Controlled atmosphere storage of cut flowers and bulbs. With the cooperation of the Agricultural Marketing Service, freshly-cut, forced King Alfred narcissus flowers were stored at various temperatures for periods up to 3 weeks in atmospheres of air, 1 percent oxygen, and 100 percent nitrogen. Flowers stored for 3 weeks at 40°F in air had a display life of 40 hours at room temperature, whereas those stored in 100 percent nitrogen had a display life of 90 hours, or as long as freshly cut flowers.

Long term storage of lily and iris bulbs was initiated. At 70°F lily bulbs stored in air formed roots and sprouted within 2 months; those stored in 1 percent oxygen remained dormant up to 6 months. Subsequent forcing was satisfactory. Similar bulbs stored at 38° in air and in 1 percent oxygen remained dormant for 6 months. Forcing response is being evaluated. Preliminary results indicate that the low oxygen storage slightly delays flowering but produces better quality plants than bulbs stored in normal air.

Wedgewood iris bulbs sprouted sooner in 1 percent oxygen at 60° than those stored in air but development of undesirable storage effects (very short stems and leaves) was delayed by the low oxygen. Similar bulbs kept dorment at 86° then vernalized at 50° bloomed slightly later after low oxygen storage but without reduction in quality.

6. Storage of Easter lily bulbs - dormancy maintained by warm temperatures. Temperatures of 70° to 80°F maintained dormancy in lily bulbs with fewer damaging side effects than follow the usual storage at 33° to 35°. Bulbs produced in the cool Pacific Northwest remained dormant at lower temperatures than did bulbs of the same cultivars produced in Georgia and Florida. Maintaining dormancy by high temperature increased vernalization requirements for prompt forcing.

7. Variable temperatures during vernalization produced better lilies. Cool storage of lily bulbs is necessary for accelerated forcing. Diurnal fluctuations in controlled storage temperatures cause production of short, leafy, heavily budded plants similar to those started in variable-temperature cold frames.

8. Iris. Post-curing storage treatments govern forcing response. Storage of Wedgewood iris bulbs at 55° after heat-curing prevented them from responding to subsequent vernalization prior to forcing. In contrast, storage of heat-cured bulbs at 60° for 5 days, after holding at 65° and before vernalization, accelerated flowering. Exposure of the bulbs to atmospheres containing 1, 5, or 10 parts per million of ethylene just prior to vernalization accelerated flowering by about 8 days. Ethylene treatment after vernalization was ineffective. (In cooperation with the Western Washington Experiment Station).

9. Control of green algae on clay flower pots. New clay pots that were dipped in a water solution of Biomet 66 (a quaternary N-alkyl dimethyl benzylammonium chloride with tributyl tin oxide, used for slime control in paper mills) remained free of algae under greenhouse conditions for periods up to more than a year, depending upon concentration used. Growth of azalea test plants was unaffected.

10. Fertilizer for daylilies. Little or no difference in the number of scapes or in weight of clumps resulted from differences in amounts or kinds of fertilizers applied to moderately fertile garden soil.

11. Easter lily.(Georgia cultivar) (a) Bulb production. In Georgia, soil fumigation with 80 percent dichloropropene-dichloropropane (D-D) and 20 percent methyl isothiocyanate (Vorlex) at 5 gallons per acre, applied with a single shank injector to 4-foot rows prior to planting, resulted in a highly profitable increase in yield of Easter lily bulbs. Methyl bromide bed fumigation, (10 lbs. to 1000 sq. ft.) also greatly increased yield from bulbs and bulb scales. Neither nitrogen sources (sodium nitrate, ammonium nitrate, ammonium sulfate, and uramite) nor double the customary amount of sodium nitrate significantly affected bulb yields. Spacing bulbs in the field row (2,3,4,6, and 8 inches) and planting depth (1,2,4, and 6 inches) did not significantly influence yields. This work was in cooperation with the Georgia Coastal Plain Experiment Station.

(b) Forcing. In Georgia, Easter lily bulbs potted September 19, plunged in soil outside and brought into the greenhouse at intervals from November 26 to January 10, required from 115 to 85 days in the greenhouse to bloom. The time decreased with length of outdoor exposure. Better shaped plants with more buds resulted from these bulbs than from bulbs cooled at 35° to 40°, potted, and placed directly in the greenhouse. A 9-hour day did not reduce stem length enough to justify its use and it did not affect bud number. (In cooperation with the Georgia Coastal Plain Experiment Station).

12. Cyclic lighting for controlling growth and flowering of photoperiodic plants. For most long day species, 6 hours of continuous incandescent light, in the middle of the night, at intensities greater than 20 foot candles promoted stem elongation and early flowering. The same results were obtained with 5 to 10 foot candles of the same light source when given for a total of 36 minutes as cycles of 1 minute light and 9 minutes dark, during 6 hours in the middle of the night.

13. Garden annuals - Controlling germination by use of light. (a) Seeds of certain cultivars of petunia, snapdragon, impatiens, kalanchoe and ageratum required light for germination in a narrow range of temperature. Light (fluorescent and incandescent) inhibited germination of gazania, vinca, portulaca, phlox, zinnia and cyclamen. Salvia, statice, poppy, torenia, celosia, marigold, alyssum, coleus, and pansy germinated equally well in light or dark over a broad range of temperature (15-30°C).

(b) Use of N-dimethylaminosuccinamic acid (B-Nine) to control height. B-Nine, when sprayed on the foliage at concentrations of 0.25 to 1 percent when the stems of plants started to elongate, held down the height of the following plants to a desirable degree: China aster, Boston daisy, annual phlox, centaurea, American marigold, petunia, snapdragon, salvia, celosia, cleome, perilla, and zinnia. Plants sprayed several times at weekly intervals produced compact plants. The effect of the growth retardant was maintained by spraying the plants in the garden every 4 to 6 weeks. B-Nine was relatively ineffective on coleus, gaillardia, gomphrena, French marigold, and pansy.

14. Rhododendron. Liners of 25 Rhododendron cultivars responded to soil applications of Phosfon (2,4-dichlorobenzyltributyl phosphonium chloride) and foliar applications of B-Nine (N-dimethylaminosuccinamic acid) by slowing growth and initiating flower buds. When applied at start of vegetative growth, one soil drench of Phosfon and spraying with B-Nine 3 to 4 times at monthly or bimonthly intervals were both effective. The plants were grown in the greenhouse with normal daylength plus 2 to 4 hours of artificial light. Liners of Roseum elegans were flowered at any time of year by treating the plants with the growth retardant, growing them on long days for 3 to 4 months, placing them in cool storage for 2 months and forcing them into flower 6 weeks later.

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SHADE, ORNAMENTAL AND WINDBREAK TREE CULTURE, BREEDING AND DISEASES
Crops Research Division, ARS

Problem. Homes, farmsteads, and municipalities have huge sums invested in shade trees and windbreaks, and more and better plantings are urgently needed in countless localities. Each year thousands of valuable shade trees are killed by diseases. Removal of dead trees is expensive in cities, and decades are required to replace mature trees killed by disease. Costs of control measures now available are estimated at several million dollars per year and are increasing; there is need to develop more efficient controls, including disease-resistant types of trees. There are numerous leaf spot diseases of trees, and the causal organisms of many are as yet unknown. Numerous diseases of still unknown cause continue to kill sweet gum, scarlet oaks, pin oaks, and white ash in home and ranch plantings. The climate of the Great Plains with its low rainfall, high winds, hot summers, and cold winters makes it difficult to establish woody plantings and research is needed to improve methods of establishing woody plants under such conditions. Hardiness, species adaptation, planting distances and arrangements, responses of plantings under different environments and the nature of conservation of moisture and soil by windbreaks are problems that require additional research. Studies are needed to measure crop responses to windbreaks of various types under different conditions in comparison with other means of soil and crop protection from wind.

USDA AND COOPERATIVE PROGRAM

In Department research special attention is being given at Beltsville, Maryland, and Delaware, Ohio, to the search for chemical cures for trees affected with Dutch elm disease; and at Beltsville, Maryland, and Tifton, Georgia, to chemical controls for mimosa wilt. Limited, but important research on diseases of live oak, especially live oak canker, and blight of sweet gum is done at Beltsville. At Beltsville, additional basic research is conducted to determine the nature of many other tree diseases of unknown cause. At Mandan, North Dakota, research is concerned with effects of windbreaks on crop yields, spread of snowfall, and soil erosion. Selection and culture of windbreak materials and other woody ornamentals are studied at Woodward, Oklahoma. The culture and handling of shade trees and windbreak studies on culture and effect on crop yields are carried on at Cheyenne, Wyoming. Research on shade tree diseases with special emphasis on Dutch elm disease is conducted at Delaware, Ohio, in cooperation with the Ohio Agricultural Experiment Station.

Research is being conducted under a contract with the College of Agriculture, University of the Philippines, on the host range and transmission of the cadang-cadang disease of coconut palm. The contract extends for 5 years, 1961-1966, and is equivalent to $13,243.64 in Philippine pesos.

The Federal scientific effort now devoted to this area totals 6.1 professional man-years divided as follows: diseases (3.0); breeding (1.1); culture (2.0).

PROGRAM OF STATE EXPERIMENT STATIONS

Windbreak research is being carried on by most of the experiment stations in the Great Plains States and by several other stations. The total program includes all major types of windbreak research. Studies in progress include effects of field windbreaks on movement of wind, soil and water, and on crop yield; genetic improvement of windbreak materials; soil and site requirements; and design, establishment and management problems, including protection from diseases and insects. During the spring of 1964, five new projects on the windbreak research program of the Great Plains States were initiated under the McIntire-Stennis program.

Windbreak research program, needs and coordination are being closely studied by the U.S.D.A. Windbreak Research Committee and the Forestry Committee of the Great Plains Agricultural Research Council. Both groups are preparing reports and their activities have already been of much value in promoting best use of total resources and evaluation of research needs. Studies on Dutch elm disease are carried on at a number of locations. The total research effort at the State stations reported here is approximately 6.0 professional man-years; of which 1.4 is for culture, 3.2 for breeding, and 1.4 for diseases.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Elm. Research continued in cooperation with the Ohio Agricultural Experiment Station. No seed were set from self-pollinated elm flowers, but 34 seeds and 18 plants were obtained from the intraspecific crosses. In addition, 95 plants were grown from open-pollinated seed of the resistant trees from the Netherlands. A method of propagating breeding material of American elm from root cuttings under mist was developed.

2. Woody ornamentals. At Mandan, N. D., trimmed hedges of Rhamnus cathartica, R. saxatilus, Syringa chinensis, S. japonica and Caragana arborescens have maintained best growth, form and survival of 30 species tested over a long period of years. One columnar type Ulmus pumila hybrid, six U. pumila hybrid selections, and one thornless Gleditsia triacanthos have maintained satisfactory growth and survival sufficient to warrant testing them over a wider area. Propagated material of columnar elm and honey locust were available for wider trial in 1964.

At Mandan, N. D., three Celtis occidentalis selections and 12 Ulmus pumila selections were planted out for seed orchard breeding stocks. Propagated material of 11 of the 12 elm selections were made available for distribution to the Soil Conservation Service Plant Materials Section. Twelve Caragana arborescens selections were made available for further selective work on growth form and type. At Cheyenne, Wyoming, 15 Juniperus selections are being propagated for breeding stocks in windbreak and hardiness studies.

Breeding to improve hardiness,range, and adaptability of native dogwood, junipers and other woody ornamentals is being initiated at Cheyenne, Wyoming. Seeds were collected and seedling populations are being grown of Amur maples selected in Wyoming for superior foliar color, form and fruiting habit. Seedling populations are also being produced of Wyoming Service-berry from seed parents selected for fruitfulness, form and freedom from rust galls. Seedling populations are now being produced from superior Russian olive plants that bore orange or red colored fruits.

B. Diseases

1. Elm. In systemic treatments, two chemicals, the sodium and amino forms of trichlorophenylacetic acid, were tested extensively, but no evidence of Dutch elm disease control could be observed. The effect of very heavy liming of soil on Dutch elm disease was tested at Delaware, Ohio. Elms grew poorly in the limed plot. With trees inoculated with Ceratocystis ulmi, the dieback per tree in 2 limed plots averaged 54 and 64 inches, respectively, compared to 85 inches in the unlimed plot. All work at Delaware, Ohio, is cooperative with the Ohio Agricultural Experiment Station and the Forest Service.

Water transport is reduced in diseased elms soon after inoculation with C. ulmi. Transpiration rates of inoculated susceptible U. americana seedlings declined more following inoculation than in uninoculated controls. In investigations on the nature of juvenile resistance to C. ulmi, extracts from seed and from 1-to 4-month-old seedlings of U. americana inhibited spore germination of the fungus. When sufficiently diluted, these extracts stimulated growth. The tops of inoculated one-year-old seedlings, in which juvenile resistance commonly occurs, displayed a significantly higher incidence of foliar wilt when excised from their roots and placed in water than did either similarly treated but non-inoculated plants or inoculated plants left on their own roots. Tests of water extracts made from roots and tops of juvenile elms showed no significant differences in their effect on spore germination and growth of C.ulmi. Water extracts from wood of inoculated and non-inoculated 6-to 8-year-old susceptible (U. americana) and resistant (U. carpinifolia 'C. Buisman') elms showed no significant differences on germination of spores or on growth of C. ulmi.

2. Mimosa. At Beltsville, Md., formulations containing a mixture of 5-amino-2,3,6-trichloro-3-amino-2,4,5 trichloro-, and 5 amino-2,3,4-trichlorophenylacetic acid isomers and 2,3,6-trichlorophenylacetic acid were evaluated as soil additives for control of mimosa wilt. All concentrations that were tried caused severe growth distortion or death of the plants. At Tifton, Ga., a tree of the resistant mimosa cultivar, 'Charlotte', which was selected and distributed several years ago, developed severe wilt. This is the first case of wilt found on this selection. Variability in pathogenicity of the Fusarium causing the wilt is probably the explanation. Selection for disease resistance of mimosa seedlings planted in heavily contaminated soil was continued at Tifton in cooperation with the Georgia Agricultural Experiment Station.

3. Saguaro. Studies were continued at the Saguaro National Monument, Tucson, Ariz., to determine causes of losses of saguaro seedlings. Of 414 plants protected by screened cages or by rodent-proof fencing, 243 survived; only 8 unprotected plants survived. No 2- to 3-inch protected seedlings were lost while 48 percent of $\frac{1}{2}$-inch protected plants did not survive. Not all losses of smaller seedlings could be charged to rodents since some small plants were killed by insects. Serological tests of pathogenic bacteria isolated from diseased cholla, barrel, prickly pear, and saguaro cacti support other taxonomic studies and confirm the identity of the bacterium causing the soft rot of the several species. A new disease of saguaro seedlings caused by the fungus, Fusarium solani, was described. Cardinal temperatures for growth of the fungus in vitro and for infection were determined. This work is cooperative with the University of Arizona and the National Park Service.

4. Coconut Palm. Attempts at mechanical transmission of the virus causing the cadang-cadang disease of coconut palms have failed to date, indicating an animal vector as a potential transmitting agent. (PL 480)

C. Culture

1. Effect of windbreaks on crop yields. (a) At Mandan, N. D., data taken on the windward and leeward sides of a non-competitive barrier gave yields in the first 20 heights on the leeward side that averaged 35 percent greater than those of the same area on the windward side. Yields beyond 20 heights on the leeward side were very similar to those on the windward side. The crop was affected by drought. Test weights averaged 1 to 3 pounds more on the windward side.

Four areas were sampled on the lee side of a mile-long 8-row shelterbelt. Two of these areas were cropped to wheat the previous year; one was in corn; and one was summer-fallowed. Previous treatment appeared to affect yield more than windbreak. Wheat grown after corn and fallow gave yields of 16 to 17.5 bushels in the first 15 heights and over 21 bushels beyond that point. Continuous wheat gave yields of 15.5 to 17.5 bushels in the

first 10 heights and of less than 13 bushels beyond that point. The continuous wheat area had less stored moisture in the soil than did that following corn and fallow. In this latter the windbreak apparently protected the wheat crop in the first 10 heights from severe drying and shrinking of grain to an extent that yields were greater than when the crop was exposed to the full force of the wind. Corn and wheat growing on the windward side of the shelterbelt showed severe nitrogen deficiency in the first 2 heights or 55 feet.

Non-competitive field windbreak barriers having densities of 43 percent in the top half and 21.5 and 14.5 percent in the bottom half reduced wind velocities on their respective leeward sides as follows: 73 and 74 percent at 2.5H; 67 and 68 percent at 5H; 75 and 74 percent at 7.5H; 83 and 80 percent at 10H; 84 and 78 percent at 12.5H; 86 and 83 percent at 16H; and 90 and 82 percent at 20H. The barrier having the least bottom density consistently gave the greatest wind reduction at a distance of 5 and more barrier heights.

(b) Cheyenne, Wyoming workers obtained wheat yield data at 2H, 3H, 4H, 5H, and 10H distances from a single row of Russian olive trees approximately 10 feet high near Slater, Wyo. This data indicated an increase in yield at distance 4H (30-40 feet) with lowest yields occurring at 10H and 2H.

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INSECT CONTROL ON ORNAMENTAL SHRUBS, FLOWERS AND TURF
Entomology Research Division, ARS

Problem. Ornamental shrubs, flowers, and turf are damaged by the feeding of a variety of insects and mites. They are also damaged by a variety of diseases spread by insects. More effective and safer control measures are needed for many of these pests. Knowledge of the basic distribution of insect pests of these plants and information on their biology are required to provide a sound basis for the development of practical, effective, and safe control measures. Insecticidal and cultural methods of control that will not affect adversely the growing plants or natural enemies of the pests or result in objectionable residues are needed. The nature and cause of resistant strains of insects and mites and means of overcoming or preventing their resistance to insecticides require continuing investigation. The role and use of biological control agents should be more fully explored and efforts made to integrate biological control with insecticidal and cultural control methods. Use of controlled light and other physical factors as possible means of controlling greenhouse pests should be studied. Increased emphasis should be placed on the search for insect attractants, chemosterilants, and growth or reproduction-affecting substances.

USDA AND COOPERATIVE PROGRAM

The Department has a long-range program of basic and applied research on insect and mite pests of ornamental shrubs and flowers at Beltsville, Md., Farmingdale, N. Y., and Sumner, Wash., in cooperation with State Experiment Stations of Maryland, New York, Oregon, and Washington, and with the Crops Research Division; and on turf insects at Moorestown, N. J., and Geneva, N. Y., in cooperation with the State Experiment Stations of New Jersey, New York, and Michigan, and the Northern Utilization Research and Development, Plant Pest Control, and Agricultural Engineering Research Divisions of ARS.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years. Of this 0.4 man-year is devoted to basic biology and nutrition; 1.8 to insecticidal control; 1.2 to biological control; 1.0 to insect sterility, attractants, and other new approaches to control; 0.1 to evaluation of equipment for insect detection and control; 0.4 to insect vectors of diseases; 0.6 to insect control treatments for commodities regulated by plant quarantine; and 0.5 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The research program in the States on insects affecting ornamental shrubs, flowers and turf is providing valuable information. Surveys are being conducted to determine the occurrence and abundance of insects and mites and their natural enemies. Investigations are underway to evaluate the extent and amount of damage caused by injurious species. Studies of seasonal life histories form a basis for developing practical control measures. Insects

are reared in the field and collected for laboratory observation on the duration of life cycles in relation to temperature and other environmental factors. This information is used to determine which types of control methods would be used for most satisfactory results.

Principal emphasis is placed on chemical controls due to (1) the sporadic nature of insect and mite attacks on many ornamental plants; (2) the need for extremely effective control in nurseries to prevent dissemination of pests; and (3) the comparatively permanent nature of plantings of most ornamentals and turf grass which prevents the use of many cultural control methods. As new chemicals become available, they are evaluated for safety, phytotoxicity and effectiveness in controlling injurious insects. Various formulations, schedules, concentrations and application rates are tested. Recently, increasing emphasis is being placed on the use of systemic insecticides on ornamentals because of their greater ease of application, and reduced environmental toxicity hazard.

Resistance of certain mite species to control chemicals also is being studied. The incidence and degree of resistance is being determined, and the morphology and physiology of affected strains of mites studied to identify the factors responsible. Biochemical methods are being employed to determine differences in physiological systems not observable in behavior and morphological studies.

The State Stations are devoting 16.0 man-years to the research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Insect Pests of Ornamentals. At Sumner, Wash., the orange tortrix was successfully reared in numbers on an artificial diet. Development required 51 days from egg to adult at temperatures ranging from 65 to 80° F. and 14 hours of artificial light. The egg stage required 9 days, the larval stage 33, the prepupal stage 2, and the pupal stage 9. The female lays an average of 224 eggs the night following mating. Mating usually takes place between midnight and 6 a.m. and was never observed without at least 2 hours of darkness. Females taken from the mating and oviposition cages containing 2 males per female contained as many as 3 spermatophores. The last one received by the female was much smaller than the previous two. In one instance, the third spermatophore actually was partially outside the bursa copulatrix.

Possibility of mass rearing the omnivorous leaf roller was demonstrated at Beltsville by the successful rearing of larvae on the alfalfa meal-vitamin-agar medium as used for red-banded leaf roller at the Vincennes, Ind., laboratory. Of newly hatched larvae placed in jelly dishes of medium, 80% reached maturity. Presence of a female attractant in this species was indicated by males coming to screened cages containing a virgin female or to plastic dishes in which virgins were confined.

At Farmingdale, N. Y., as many winged aphids were captured in 10 yellow pans of water spaced 1 foot apart as when spaced 8 feet apart. This finding supports previous evidence that aphids are attracted to yellow from only a very short distance. More aphids were caught per unit yellow area on sticky board traps than in the water-pan traps.

B. Insecticidal and Cultural Control

1. Insects of Ornamentals. In greenhouse tests at Farmingdale, N. Y., and Beltsville, Md., dichlorvos at 0.5 g/1000 f^3 applied with hand-carried electric mist sprayers killed green peach aphid and whitefly adults; at 1 g/1000 f^3 it killed resistant spider mites and citrus mealybugs. About 200 kinds and varieties of ornamental and vegetable plants were treated without injury except for slight specking on one petunia variety and on Shasta chrysanthemum. Dichlorvos residues on greenhouse tomatoes from mist spray applications and from aerosols were similar. Preliminary tests indicate that electric mist sprayers offer promise for use with concentrate sprays in greenhouses.

In pot drench tests with systemic insecticides at Sumner, Wash., on iris in greenhouse benches, phorate, dimethoate, and Meta Systox-R at 1/4 cupful per 4-in. pot of a 1 lb/100 gal. solution gave complete control of the tulip bulb aphid for the entire forcing period. Meta Systox-R applied in the same manner also gave complete control for 120 days of the western lily aphid on greenhouse forced Ace and Croft lilies.

At Beltsville, binapacryl and Pentac residues in laboratory tests were approximately equal in persistency against resistant spider mites and Morestan was less persistent. In addition Morestan was extremely toxic to lima beans.

2. Japanese beetle. The search was continued at Moorestown, N. J., for new insecticides that could be substituted for the chlorinated hydrocarbons for control of Japanese beetle grubs in soil. Carbaryl at the rate of 10 pounds per acre was effective for 90 days against newly hatched grubs.

Soil samples from areas in eastern Illinois treated with granular aldrin, dieldrin, or heptachlor for control of Japanese beetle larvae were analyzed. Dieldrin appears to be the most persistent of these insecticides with 10 to 18% of the original amount remaining in the soil after 9 years. From aldrin treatments 5 to 23% of aldrin plus dieldrin remained after 3 years. Heptachlor-treated plots showed 2 to 35% heptachlor plus heptachlor epoxide remaining after 3 years.

C. Biological Control

Japanese beetle. During 1963 a survey of the status of the milky disease bacteria was made in 11 counties of New Jersey where the pathogen had been colonized during 1939-1941. The milky disease bacteria were found in all

grasslands where the pathogen had been colonized and they had spread to other grasslands and cultivated fields within 2 miles of the colonization sites.

D. Insect Sterility, Attractants, and Other New Approaches to Control

1. Insects on Ornamentals. At Beltsville, Md., over 99% of adult omnivorous leaf roller females were rendered sterile by exposure to gamma radiation at a dosage of 16 kr. Thirty-two kr. were required to sterilize adult males to the same extent.

A unique nonchemical method was used experimentally to repel flying aphids and prevent them from spreading plant disease. The number of aphids flying to gladiolus plots was reduced 96% by aluminum sheets that were spread between the rows of plants and around the borders of the plots in tests made in New York in cooperation with Cornell University. Indian ironweed, a potential oilseed crop, was protected in a similar manner in experiments conducted in Maryland. Aluminum powder sprays on the plants were about as effective as aluminum foil but lacked persistence.

2. Japanese Beetle. At Moorestown, N. J., successive matings of female Japanese beetle with fertile and sterile males resulted in some batches of eggs that developed normally and others that failed to hatch. Apholate, metepa, and tepa sterilized adult beetles but were ineffective when applied to immature stages.

E. Evaluation of Equipment for Insect Detection and Control

The investigation of blacklight lamps as lures for the adult European chafer confirmed that traps with 6-watt blacklight lamps operated in competition with those with 15-watt lamps captured only about one-half as many chafers as did the traps with the higher wattage, but when operated independently, the efficiency of the 6-watt trap in capturing chafers approached that of the 15-watt trap.

The blacklight fluorescent lamps manufactured now by the General Electric Company have a new phosphor referred to as the Philips phosphor. This produces a peak radiation at a slightly longer wave length than the conventional phosphor, but the outstanding difference is the much greater energy output toward the blue in the 4,000 Angstrom region. Tests demonstrated that blacklight lamps equipped with either of these phosphors were equally attractive to chafers.

F. Insect Vectors of Diseases

1. Insects of Ornamentals. In cooperative tests with Crops Research Division at Beltsville lily rosette was transmitted by the melon aphid for at least 12 days after removal from source virus. It should therefore be classed among the persistent viruses. Tests using whitefly, thrips, and

aphids to transmit yellow spot virus of geraniums have produced negative results.

Pronounced green and yellow mottle, large ringspots and chevron patterns in amaryllis leaves, suspected of being symptoms of a virus infection, have been duplicated in healthy seedling amaryllis with inoculations of sap and in transmission tests with the green peach aphid. The virus produced cucumber mosaic virus disease when transmitted mechanically or with aphids to tobacco and other indicator plants. Identification of the malady in amaryllis as a virus disease and determination of its mode of transmission have furnished a basis for making control recommendations to commercial amaryllis growers and home owners.

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PEST CONTROL TECHNIQUES AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. Many pests attack economic crops in the United States, resulting in billions of dollars of loss to the farmer each year. Plant diseases, weeds, insects, and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment. Effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended.

Thus, equipment to control a wide variety of pests on a wide variety of crops is required. This requirement is partially met by the sprayers, cultivators, dusters, and soil injection equipment now available. However, mechanical cultivation does not always produce satisfactory weed control, and it is time consuming and costly. It is believed that with sprayers and dusters now used, often no more than 10 to 20 percent of the chemical goes onto the plant. Methods of applying nematocides in the soil do not always result in uniform nematode control, and untreated soil below the treated zone, in untreated pockets, and at the soil surface, provide sources for quick reinfestation.

There is need for improved methods of much greater efficiency for applying pesticides to plants and the soil. This implies a need for considerable fundamental study of small particle behavior, of radically new methods of applying chemicals, and of the movement of liquid and gaseous chemicals in the soil. The sales of present equipment are not great enough, nor are the manufacturers large enough, to permit industry to make a very great investment for research in this field.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers' problems. Cooperation is with the State Agricultural Experiment Stations of the states mentioned, unless otherwise noted. At Wooster, Ohio, basic research is conducted on fundamental studies of aerosols and on various spray formation devices. Soil fumigation research also is conducted at Wooster, Ohio. Disease control research is also conducted at Wooster, Ohio. Pest control equipment research for certain crops is conducted: for cotton at Auburn, Alabama, Stoneville, Mississippi, Shafter, California, Lubbock, Texas; and (particularly for boll weevil control) at State College, Mississippi; for vegetable crops at Forest Grove, Oregon; and for brush control at Mayaguez, Puerto Rico,and College Station, Texas.

The Federal scientific effort devoted to research in this area totals 14.4 professional man-years, of which 1.7 is devoted to basic studies in aerosols and spray formations, 1.0 to soil fumigation, 1.0 to insect and disease control by ground equipment in vegetables and other low-growing crops, and 0.9 to aircraft equipment for application of pesticides to vegetables and other

low-growing crops; and 1.0 to aerial spray equipment for forest insect control.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.7 man-years is devoted to this work on all crops; figures are not available for work on florist, nursery and shade tree crops.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Studies in Aerosols and Spray Formation.

1. Mathematical and experimental studies on the basic transport, spreading, and distribution processes for fine particles suspended in turbulent gases were continued at the Pioneering Research Laboratory on Physics of Fine Particles at Wooster, Ohio. An instrumentation system is under development for measuring the distribution of fluorescent-traced particles on deposition surfaces to facilitate the study of relations between deposit distribution and the turbulence producing it. A method of spectral analysis has been developed which appears to be applicable to the measurement of surface deposit, but which needs further study. The use of a tape recorder has made experimental procedure immeasurably easier than if one attempted to process the "live" signal directly. Additional work is being carried forward in the areas of heat and moisture diffusion in fine-particle starch doughs, and in electrical diffusion of clay suspensions.

B. Soil Fumigation.

1. Field treatments were made in cooperation with the Ohio Station in order to study and develop methods and equipment for applying chemicals to soil for the control of crop pests. A number of volatile materials are now available in pressurized cylinders or bottles similar to the containers used for oxygen, nitrogen and other compressed gases. By using an appropriate regulator, these materials are easily applied by the field cultivator equipment with injector blades. Applications of this type made for control of Verticillium in vegetable plantings gave substantial increases in yield but the materials do not give the desired control of this disease. Measurements made of cherry trees planted in soil treated with several different nematocides in 1957 and 1960 show increased twig growth and greater spread of branches than in untreated plantings.

Applications of herbicides by a rotary tiller type of applicator, operated with forward travel per blade cut ranging from 1.5 to 4.7 in., show best result with the short cut. The short cut is believed to give a better resultant mixing of non-volatile chemicals with the soil.

Latex, asphalt and wax emulsions were applied to soil as surface mulches. This had previously been found to increase plant growth including weeds. Several formulations including different herbicides were applied. Generally these formulations appeared to produce some seedling injury and reduction in stand in vegetables on which they were used.

C. Insect and Disease Control by Ground Equipment in Vegetables and Other Low-growing Crops.

1. Both hydraulic and air blast sprays were applied to sugar beets in cooperation with the Ohio Station and Northern Ohio Sugar Company. Hydraulic applications were designed to study seasonal timing of spray applications, effect of interval between applications, various copper and oil combinations, and control achieved by other fungicides. Results were obscured by dry weather which prevented disease development. For example, although seven sprays of a copper and oil fungicide, beginning July 16 and applied at 10-day intervals, gave the best disease control, the yield of beets and sugar was no better than five sprays applied at 15-day intervals or three sprays at 20-day intervals.

A series of seven different air blast sprays were applied to sugar beets at 10-day intervals. Variations included gallonage applied, swath width, fungicide used, and operating pressure. Dry weather permitted little development of Cercospora leaf spot infection in the beet foliage. All treatments, therefore, gave excellent control of this disease. Manzate and copper with oil applied at comparative rates, showed a slightly higher sugar yield in favor of the former. Copper analyses were made of deposit samples taken across a 100-ft. double swath sprayed from both sides. These show a higher center deposit at a 40 gal. per acre application rate, when compared to rates of 20 and 10 gal. per acre. Other sample analyses show deposit patterns are affected by size, number, and placement of nozzles and by wind velocity and direction.

Sprays were applied to sugar beets at another location to study the effect of supplemental oils in improving the fungicidal action of fixed-coppers. The experiments indicate that increasing quantity added or viscosity of the oil, within the limits studied, increased the adhesion of copper to this foliage.

Sprays were also applied to a mixed vegetable planting to study spray adhesion on various types of foliage (pubescent or glabrous). The effect of dew and rainfall was included in this study, but extreme dry weather interfered with this part of the experiment. The results suggest that smooth foliage should be sprayed more frequently and with a higher dosage than hairy foliage, to obtain comparable disease control.

D. Aircraft Equipment for Application of Pesticides to Vegetables and Other Low-growing Crops.

1. Major project activities in 1963 included the rebuilding of a Bell 47D1 helicopter which was obtained by transfer in 1962. Operations consisted of dismantling all major components, sandblasting, overhauling, inspecting for flaws, painting and rebuilding the entire unit. Spray equipment was designed, fabricated and fitted to the helicopter and will be used in the research investigations. In February and March of 1963, an aircraft mechanic and machinist, and an aircraft pilot, attended schools for helicopter mechanics and pilot training, respectively.

A series of bait insecticidal sprays were applied with the Rawdon T-1 airplane to a crop of peas for the control of the pea weevil in canning peas. These applications were made near Woodburn, Oregon, in cooperation with the Entomology Research Division. The flight elevation was about 25 ft. and the swath spacing 50 ft. The bait sprays consisted of brown sugar mixed in water and endosulfan or malathion and applied at the rate of 4 gal. of formulation per acre. The object of the tests was to control the insect with a minimum amount of toxicant by use of an attractant bait. In one test area the results were inconclusive. In another area 84 to 93 percent control was obtained at 48 hrs. after the application. The tests showed that the bait spray will suppress the pea weevil population on canning peas although not 100 percent was obtained.

Assistance was given to the Forest Service in conducting exploratory spray distribution tests with a helicopter owned and operated by Evergreen Helicopters of McMinnville, Oregon. The results of these pattern studies were used by the Forest Service as a basis for a series of aerial pesticide application tests with helicopters to control the Western Hemlock looper in Pacific County, Washington.

A spray distribution test series was conducted in cooperation with the Piper Aircraft Corporation using a Piper Pawnee PA-25-235 furnished by the Company. These data showed that a reasonably uniform and satisfactory deposit pattern as well as swath width could be obtained with a low density application rate (1-3 gal. per acre) when an asymmetrical nozzle arrangement was used. A satisfactory deposit pattern was not obtained for the high density applications. Tests were discontinued when the aircraft was recalled by the Corporation because of other commitments. These high density tests will be continued as opportunity permits.

A limited number of tests were conducted with a Piper Pawnee PA-25-235 aircraft owned by Sam Whitney of Newberg, Oregon. This aircraft was equipped with a hydraulically driven spray pump instead of the externally mounted windmill type drive and external mounting used by Piper Aircraft. The change in pump mounting did not appear to affect the spray pattern being deposited.

E. Aerial Spray Equipment for Forest Insect Control.

1. Since a helicopter was not readily available at Beltsville, some spray studies were made in cooperation with the Forest Service, using a PA18A fixed wing airplane at 45 to 50 m.p.h. to simulate helicopter application. The degree of spray atomization is an important factor affecting the distribution and effectiveness of aerial sprays. There is considerable information on the atomization produced by various nozzles on fixed wing aircraft but for helicopters such information is very limited. Two flat spray pattern nozzles, T8004 and T8006 (Spraying Systems Co.) with flow rates of 0.4 and 0.6 g.p.m. were used with the orifice directed forward and down about 40 degrees to the thrust line of the plane. The atomization was 176 microns mmd from the former and 179 from the latter - no significant difference. About this same atomization (180 microns mmd) was produced by a hollow-cone nozzle, D4-25, with an output of 0.29 g.p.m. The orifice was also directed forward and down 40 degrees. Thus, for this atomization of 176 to 180 microns, the flat spray nozzles would be preferable to the hollow cone nozzles because a smaller number of them would be required to provide a given output.

On the studies with heavy aircraft a series of flights were made with a TBM airplane at 200-ft. altitude to study spray distribution from this height as compared to that from lower heights (100 to 150 ft.). Flow rate of the plane was 107 g.p.m. for an application of 1 g.p.a. over a 300-ft. swath at 170 m.p.h. Based on a total of 20 flights, 10 at each height, there was no difference between the two heights at the 0.25 g.p.a. deposit level. At deposit levels of 0.1 and 0.2 g.p.a. swath width was slightly greater at the 200-ft. height but the reverse was true at deposit levels greater than 0.25 g.p.a. These tests showed that the present recommendations of a 300-ft. swath for a TBM will result in a deposit of not less than about 0.15 g.p.a. over this width. Considering overlap of adjacent swaths, deposit should be adequate for control of most forest defoliators. The average spray recovery was 73 percent.

A pilot test of an aerial application of B. thuringiensis, a biotic insecticide, was carried out for control of the gypsy moth in New York State. A Piper PA18A was used to apply 2 gal. per acre using a 75-ft. swath width. A one percent concentration of a water soluble fluorescent tracer, Laucophor C 6202 (Sandoz Chemical Works) was added to the spray mix. Samples of the spray were collected on white Kromekote cards placed in the plots. After spraying, the cards were irradiated with ultraviolet light. The tracer was found to be a very good indicator of spray deposit. The application reduced gypsy moth populations but did not effect acceptable control. No further large scale field applications of this material will be made until additional laboratory work is done to improve its toxicity.

The development of methods for measurement of spray deposit by use of fluorescent tracers has been continued. Attempts are being made to quantitatively assess spray deposits on paper cards. Position and intensity of ultraviolet excitation source has been studied and an enclosure constructed in which sprayed card samples can be assessed. Calibration work is in progress. The measurement of water sprays either by fluorescent tracer or estimation from dyed card standards is an important problem to be investigated during the coming year.

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ELECTRIC AND SOLAR EQUIPMENT FOR ENVIRONMENTAL CONTROL
Agricultural Engineering Research Division, ARS

Problem: Current scientific and economic developments indicate that production of vegetables and flowers in the future may require complete control of soil, light, and atmospheric conditions. Engineering problems associated with the application of light to plants have increased in recent years with the need for growth rooms for research and commercial use of light for growing crops.

USDA AND COOPERATIVE PROGRAM

A new program at Beltsville has been established whereby engineers from the Agricultural Engineering Division cooperate with the Crops Division on basic studies of light and thermal environment and their relation to plants in growth chambers. Equipment for the application of carbon dioxide to plants is under development at Pullman, Washington, in cooperation with the Departments of Agricultural Engineering and Horticulture of the Washington Agricultural Experiment Station. The Federal scientific effort devoted to research in this area totals 5.4 professional man-years, of which 1.8 are devoted to plant environment equipment.

PROGRAM OF STATE EXPERIMENT STATIONS

Several of the States are engaged in programs of basic and applied research on the possible use of some of the various forms of electrical and physical energies as a means for improvement of the potential capabilities in farm production.

Investigations in progress, many of which are cooperative with the Department, involved the evaluation of the use of radiofrequency energy for treatment of grains to destroy insect infestation and treatment of seeds to improve their germination characteristics; exploration of the feasibility of using ultrasonics and electric shock to control rats, mice and birds; studies of the possibilities for a major advancement in the technology of small particle depositions through the application of electrostatic, thermal or other inertial forces; and use of light sources of various wavelengths for attracting and collecting insects which infest many of our economic crops.

A total of 2.0 professional man-years effort is devoted to this work.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Plant and Product Environmental Equipment

1. Carbon Dioxide Control in Greenhouses

The study of the engineering problems involved in the measurement and control of the carbon dioxide concentration in an air-supported plastic greenhouse was continued at Pullman, Washington, in cooperation with the Agricultural Engineering and Horticulture Departments of the Washington Agricultural Experiment Station, Washington State University.

The control system tested during the previous winter growing season was used throughout this report year. This control system allowed automatic control of the carbon dioxide concentration in four greenhouses at any constant level between atmospheric and 2,000 parts per million (ppm). Two new control systems have been built and some testing conducted. Both of these systems are designed to vary the carbon dioxide concentration with respect to the available light intensity. Crops of lettuce, radishes, stocks, carnations and okra were grown under controlled carbon dioxide concentration. The concentrations studied included atmospheric (about 300), 400, 800, 900, 1,200, 1,600, and 1,800 ppm. The yield (fresh weight of heads) of Bibb lettuce was doubled, or nearly doubled, when grown under increased carbon dioxide concentration of 900 and 1,800 ppm. Of equal significance was the observation that acceptable crops of lettuce could be produced at higher than optimum growing temperatures with increased carbon dioxide concentration. Radishes (Cherry Belle, White Icicle) exhibited a two- to four-fold increase in root weight and approximately a two-fold increase in root weight to top weight ratio. Stocks, a fast growing floral crop, produced a shorter, heavier, thicker stem, indicating a more rapid rate of carbohydrate accumulation. Carnations came into production approximately three weeks earlier, produced more total flowers and more flowers of a higher grade. Okra exhibited an increase in stem diameter, fresh weight, dry weight, leaf area, fresh weight per leaf area and dry weight per leaf area. For all of the crops and carbon dioxide concentrations studied during the year, production was increased, however, in some cases maximum production occurred at concentrations less than 1,800 ppm.

2. Plant Growth Equipment and Techniques

At Beltsville instrumentation is under development for use with a data logger for measuring humidity, light, air quality, air velocity and plant movement. In cooperation with Crops Research Division a far-red light source, a temperature gradient chamber, and a light-tight shutter for rapid light cycling were developed.

Experimentation continued through the year in a commercial growth chamber to determine effects of different lamps on the growth of beans. First experiments compared special commercial design fluorescent lamps to the standard cool white fluorescent lamps. After several experiments we found no increase in growth from the special lamps.

Experimentation then proceeded to compare fluorescent light alone and with incandescent light added. It was found that incandescent light definitely has an effect on increasing growth. The effect is complicated by other conditions such as ambient temperature, heating effect of incandescent light, the time after planting and duration of incandescent light. The greatest single effect so far determined occurs by having incandescent light on beans for four 16-hour periods with fluorescent light starting the 12th day after planting.

A commercial angle transducer has been adapted to measure plant growth, leaf movement, lateral stem movements or other plant movements. As small as .005 inch can be recorded on either a milliamp or milliwatt recorder. The signal can also be put into the data logger. Tests carried out with this sensor include growth and primary leaf and lateral stem movements of beans. Seedling growth of dark germinated and light treated zinnia seedlings was recorded for various light treatments. Indications are that there is a pause or even a shrinkage of plant growth when lights are suddenly turned on. Many applications of this can be foreseen as a rapid means of detecting plant response to various treatments.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Pettibone, C. A.; Matson, W. E. and Ackley, W. B. 1964. Control of carbon dioxide in an air-supported plastic greenhouse. ARS 42-92. Jan. 8 pp.

II. MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY OF CUT FLOWERS AND ORNAMENTALS
Market Quality Research Division, ARS

Problem. The rapid increase in production of field-grown narcissus, gladiolus, lilies, stocks, and chrysanthemums into a multimillion dollar business in Florida, California, and other states has raised many problems in marketing. Information on methods and materials for use in packaging, on the temperature requirements and atmosphere modifications for storage and transit, and on the control of decay are among the most urgent problems.

USDA AND COOPERATIVE PROGRAM

The Department has a very limited program in market quality research on cut flowers and ornamentals, amounting to approximately 1.0 professional man-year. This research is conducted at the Fresno and Beltsville laboratories. The work on quality maintenance during transportation is conducted in cooperation with the California Floral Traffic Conference.

PROGRAM OF STATE EXPERIMENT STATIONS

Research on market quality of cut flowers at the State stations involves three distinct areas: determination of grades and standards for cut flowers, studies of the keeping quality of cut flowers under different methods of holding, and disease investigations. Studies of grades and standards for cut flowers have been coordinated into a regional project NCM-35, Market Grades and Standards for Specified Cut Flower and Potted Plant Crops. Crops included for study in this project are Easter lilies, poinsettias, snapdragons, roses, and chrysanthemums.

Studies of keeping quality include consideration of such factors as chemical preservatives; growth regulators; pH levels of holding solutions; humidity, temperature, air movement, and ethylene and carbon dioxide accumulations in storage chambers; respiration rates; use of chelating agents in holding solutions; and packaging and packing procedures. Investigations with woody ornamental plants concern storage and handling of bare-rooted evergreen nursery stock, the marketing of container-grown ornamental plants, and the packaging of selected woody ornamentals.

Numerous pathological investigations relate in part to the preservation or market quality in flowers and ornamentals.

Altogether there are 47 projects in 24 States that contribute in whole or in part to this area of research. Total market quality research effort on cut flowers and ornamentals at the State stations is approximately 11.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Quality maintenance in handling and packaging

1. Mistletoe. Mold on leaves and berries of inoculated prepackaged mistletoe was significantly greater when the mistletoe leaves and berries were injured than when they were free of injuries - suggesting the need for careful handling and packaging. Botran at concentrations of 2000 ppm controlled mold of prepackaged mistletoe in one test but failed to do so in two other tests. Alpha napthalene acetic acid (20 ppm) when used with a fungicide was fairly effective in controlling leaf and berry abscission. (MQ 2-15)

B. Quality maintenance in storage

1. Pine Seedlings. Excessive desiccation and decay may cause serious losses in conifer seedlings during several months storage. Polyethylene bags were effective in retaining quality and freshness of pine and fir seedlings. Captan, Botran, and dibromotetrachloroethane controlled Botrytis, the chief cause of decay about equally well. (MQ 2-15)

2. Roses. Reducing the oxygen level to 0.5 percent was effective in extending the storage and market life of cut roses. The addition of 5.0 percent carbon dioxide to a low oxygen atmosphere was not beneficial and, in some instances, lowered bloom quality. Storage at 32° F. was better than storage at 36°. Responses to low oxygen atmospheres varied considerably among varieties. Placing rose stems in water during storage resulted in a rapid loss of quality even in the presence of low oxygen atmospheres. (MQ 2-15)

3. Carnations. In tests at Fresno, an atmosphere of 0.5 percent O_2 and 5.0 percent CO_2 was effective in holding both white and red carnations for 4 to 5 weeks at 36° F. The same atmosphere caused slight injury to the petals at 32°. Quality was maintained best when carnations were stored without placing the stems in water after cutting. (MQ 2-15)

4. Low Oxygen Effects. Tests, in cooperation with the Crops Research Division indicated little or no beneficial effect from storage of roses (at 60° F.) and chrysanthemums (at 33° F.) in atmospheres of 0% oxygen (100% nitrogen) or in 1% oxygen with 99% nitrogen, as compared with storage in air. Lilies kept better for 3 weeks at 33° F. in 100% nitrogen than in air, but the buds from either atmosphere failed to develop completely when placed at room temperature. Floret opening was retarded in gladiolus held 1 to 3 weeks at 40° but the greatest retardation was observed in atmospheres of 100% nitrogen and in 99.75% nitrogen with 0.25% oxygen. All glads stored 1 week at 40° failed to open completely when placed in air at room temperature. Dry storage of glads in sealed polyethylene bags was as satisfactory as any treatment tested. Daffodils responded well to storage in low oxygen atmospheres. After 3 weeks at 40° F. in air, daffodils had a vase life of about 40 hours at room temperature, whereas those held in 100% nitrogen at 40°lasted 90 hours, or as long as freshly cut flowers.

At 70° F., lily bulbs stored in air formed roots and sprouted within 2 months, whereas those stored in 1% oxygen with 99% nitrogen remained dormant for as long as 6 months. Subsequent forcing was satisfactory. Iris bulbs sprouted sooner in 1% oxygen with 99% nitrogen at 60° F. than those stored in air, but development of undesirable storage effects (very short stems and leaves)was delayed by low oxygen storage.

Geranium cuttings were stored successfully for 18 days at 32° F. in an atmosphere of 1% oxygen with 99% nitrogen. Growth resumed earlier than in those held in air or in 100% nitrogen. Geranium cuttings were stored successfully for 1 week and chrysanthemum cuttings for 6 to 8 weeks at 33°in sealed 1¼ mil polyethylene bags. (MQ 2-105)

C. Quality maintenance during transportation

1. Roses. Packaging roses in film bags provides a way of maintaining modified atmospheres in air transit. In studies at Fresno, bags of roses were purged with nitrogen to rapidly lower the oxygen concentration. At 75° F., the resulting low oxygen level injured the blooms, stems, and leaves, but at 60° the level of oxygen was sufficient to maintain the flowers in excellent condition for 40 hours. Ethylene oxide (¼ percent) added to the low oxygen atmospheres in the bagged red roses increased the undesirable blue color. Immersing the stems in aluminum sulfate solution before packaging favored the retention of the red color of the petals. However, low oxygen had a greater effect on red color retention than the sulfate dip. (MQ 2-15)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Quality Maintenance in Handling and Packaging

Smith, M. A. 1963. Control of Berry and Leaf Abscission and Mold Control in Packaged Mistletoe. Plant Disease Reptr. 47:1001-1005. (MQ 2-15)

Quality Maintenance in Storage

Asen, Sam, C. S. Parsons, and N. W. Stuart. 1964. Experiments Aim at Prolonging Narcissus Display Life. Florists' Review, 134:25, 69-70. (MQ 2-105)

Quality Maintenance During Transportation

M. Uota and C. M. Harris. 1964. Quality and Respiration Rates in Stock Flowers. USDA, AMS 537. (MQ 2-15)

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing program involving a series of studies to show: (1) Detailed analyses of marketing costs and margins in the various stages and channels in handling, processing, transporting, and distributing horticultural and special crops and related products; (2) comparative efficiency and costs of present agencies, organizations, methods, and practices in performing the services involved at each important stage in taking the crop products from farms to final users; and (3) the influences on costs and efficiency of such factors as grades and standards, methods of determining and maintaining product quality, and governmental regulatory and informational programs. On the basis of results of such studies, recommendations are made on possible means of increasing the efficiency of marketing, or increasing returns to growers, and of providing consumers with the choices they desire.

The Federal scientific effort devoted to this research in F.Y. 1964 amounted to 3.1 professional man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Research in the horticultural specialties area is quite well divided between flower crops and ornamental and nursery products. Three-fourths of the projects are contributions to regional research studies. Studies on flower crops are dominantly on economic forces affecting marketing florist products in mass outlets and the effects of this development on the market structure of the industry. Of next importance are studies of merchandising practices and specific methods of processing, handling and selling flowers in retail stores. Other studies include general descriptions of retail operations and costs and returns in grading cut flowers.

Research on ornamentals and nursery is dominantly concerned with procurement, handling and distribution practices of retail nurserymen, and factors affecting trends in consumer use of various nursery crops and marketing services provided by nurserymen. Specific attention is being given to an evaluation of methods of disseminating information on plant material selections and use. Three studies are concerned with various aspects of industry structure and practices in selected areas.

A total of 14.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Structure, Practices and Competition

1. A study to analyze the economics of marketing floral products has disclosed that the florist industry and related services accounts for approximately $1.2 billion annually. According to census data the farm value of floral products increased more than 50 percent between 1949 and 1959 without any appreciable increase in wholesale prices or numbers of producing units. Personal interview surveys of retail florists in 4 Iowa cities reveal that 89 percent of the florists belonged to a wire service in 1964. Approximately 14 percent of their sales were wire sales, (both incoming and outgoing). Of the 86 percent of the sales that were not wire sales, 60 percent were made over the telephone. Florists did not have serious credit or financing problems, but most of them experienced occasional cash "squeezes" because of slow bill-collection procedures.

B. **Effect of Merchandising and Promotion Practices on Sales and Demand for Floricultural Products.** Work currently underway includes: (1) A nationwide survey of approximately 4,000 retail florists to determine merchandising, advertising, pricing, procurement, credit, service, and other operating practices; (2) analysis of economic and demographic factors as they relate to the demand for flowers; (3) evaluation of specific promotional efforts by individuals or groups; and (4) a review and summary of published research relating to marketing floral products. Completed questionnaires have been returned by approximately 2,000 or 50 percent of the sample of retail florists.

Results of an analysis of FTD wire orders show that 99 percent of the changes in number of wire orders from 1930-63 can be related to four factors--disposable income, number of military personnel on active duty, deaths and marriages. Disposable income was most highly related to wire orders, explaining 95 percent of the fluctuations. This variable represents increase in population, change in number of employed persons, and general economic growth.

Two instances of television promotion are being evaluated. One promotion was conducted for a year by 10 florists in the Binghamton, Johnson City, and Endicott, New York, area. Sales data of participating as well as non-participating florists show no significant response in total sales volume. Additionally, a television campaign involving 16 florists in the Lancaster, Pennsylvania, area during the period September 1963 to May 1964 is being evaluated. Again gross sales indicate no significant response to the promotion. In both instances an analyses of wire orders will be made to measure their reaction to the promotions. Additionally, annual wire-order sales in the two test areas involving promotion and in other cities or areas of similiar size will be analyzed in relation to: (1) Number of resident telephones; (2) number of business telephones; (3) industrial employment; (4) buying power; (5) hospital admissions; (6) drug sales; (7) general merchandise sales; and (8) deaths.

A review of marketing research relating to floral products has been completed and is now being reviewed for publication. This includes a summary and discussion of published research results and a biographical listing.